

REMARKS

The following remarks are being submitted as a full and complete response to the Office Action dated April 18, 2008. In view of the following remarks, the Examiner is respectfully requested to give due reconsideration to this application, to indicate the allowability of the claims, and to pass this case to issue.

Status of the Claims

As outlined above, claims 1, 5, 7-10, 14, 16, and 18-26 stand for consideration in this application.

Prior Art Rejections

The First 35 U.S.C. §103(a) Rejection

Each of claims 1, 5, 7, 8, 10, 14, 16, 18-20, and 23-26 was rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Mullee (U.S. Pat. 6,306,564) in view of Vaartstra (U.S. Pat. 6,242,165) and Skee et al. (U.S. Pat. 5,989,353). Applicants respectfully traverse this rejection for the reasons set forth below.

Claim 1

The Examiner asserted that Vaastra teaches equivalence of tetramethyl ammonium fluoride to ammonium fluoride in a similar cleaning composition. The Examiner further asserted that declaration submitted under 37 C.F.R. §1.132 associated with the response filed on January 17, 2008 was not sufficient to show that ammonium fluoride and tetramethyl ammonium fluoride are not equivalent in a supercritical state on the grounds that the declaration does not provide any numeric or objective data showing differences between a supercritical composition containing ammonium fluoride in comparison to those compositions containing tetramethyl ammonium fluoride, but merely provides technical reasoning. Applicants strongly but respectfully disagree.

The declaration submitted was purported to explain why ammonium fluoride and tetramethyl ammonium fluoride are not equivalent in a supercritical state although it did not present data as asserted by the Examiner. However, the specification originally submitted describes the experimental results to show that ammonium fluoride and tetramethyl ammonium fluoride are not equivalent in a supercritical state. These experimental results present unexpected and superior properties of compositions containing tetramethyl

ammonium fluoride and supercritical CO₂ over compositions containing ammonium fluoride and supercritical CO₂, as set forth below.

Experiment 1 evaluated the effectiveness of various additives including ammonium fluoride in removing residues from the surface of a silicon wafer in a solution. (See page 7, lines 13 - page 8, line 12 of the specification.) The result of Experiment 1 is shown in Table 1 on pages 7-8 of the specification. Although it is shown that the ammonium fluoride solution has a superior rate for removing residues, Experiment 1 was carried out in the solutions that did NOT contain supercritical CO₂, and was not conducted under supercritical CO₂ conditions.

Experiment 4 evaluated the effectiveness of various additives in removing residues from the surface of semiconductor wafers. The various additives evaluated in Experiment 4 are shown in Table 4 on page 10 of the specification. The compositions of the additives evaluated in Experiment 4 contain tetramethyl ammonium fluoride (TMAF) (Additives H, I, and K in various weight % and having various co-solvents); ammonium fluoride (NH₄F) (Additive G); and tetrabutyl ammonium fluoride (TBAF) (Additives J and L) and supercritical CO₂. (See pages 10, line 5 – page 12, line 1 of the specification and Table 4.) The result of Experiment 4 is shown in Table 5 on page 11 of the specification.

As set forth in the declaration submitted herewith, ammonium fluoride was not dissolved in the co-solvent ethanol because the additive did not dissolve or was not dispersed homogeneously in CO₂ and had phase separation under supercritical CO₂ conditions. Instead, Additive G was dissolved in a combination of co-solvents, namely, deionized water, acetic acid, and ammonium acetate. In Run 8 using ammonium fluoride, a water rinse was needed to remove residue since a water-soluble residue newly appeared on the surface of the silicon wafer (page 11, lines 11-13 of the specification). In contrast, in the other Runs 1-7 and 9-14 using either TMAF or TBAF, a water rinsing step subsequent to the removing step was not needed (page 11, lines 13-14 of the specification). Moreover, in the cases where the additive is TBAF or TMAF and the co-solvent is an alcohol such as ethanol, no water was substantially needed in both steps of removing residues and rinsing a wafer (page 11, lines 16-17 of the specification). Indeed, it is preferable that the supercritical CO₂ includes substantially no water, which is a hindrance for manufacturing semiconductor wafers (page 10, lines 12-14 of the specification). As such, the result of Experiment 4 clearly shows that the a composition which comprises an additive comprising fluoride selected from tetramethylammoniumfluoride, tetraethylammonium-fluoride, tetrabutyl-ammoniumfluoride,

tetrapropylammoniumfluoride, choline fluoride, and mixtures thereof is superior because it uses substantially no water which becomes a hindrance for manufacturing semiconductor wafers as recited in claim 1. (See page 11, lines 17-19 of the specification.)

Furthermore, Experiment 5 evaluated etch rates of thermal oxide in using additives H, I, and G. The result of Experiment % is shown in Table 5 on page 12 of the specification. As shown in Table 5, compared to the compositions containing TMAF such as Additives H and I, the compositions containing ammonium fluoride such as Additive G exhibit a higher etch rate. Fig. 3 also shows that the increase in the etch rate of Si in using G is sharper than those in using H and I. These experimental results show that the compositions containing ammonium fluoride such as Additive G will present difficulty in being controlled by adjusting the concentration of additive and ethanol and their ratios, compared to the compositions containing TMAF such as Additives H and I.

In sum, from these experimental results, it is clear that compositions containing tetramethyl ammonium fluoride and supercritical CO₂ present unexpected and superior properties over compositions just containing ammonium fluoride and supercritical CO₂. Therefore, compositions just containing tetramethyl ammonium fluoride and supercritical CO₂ are not equivalent to compositions containing ammonium fluoride and supercritical CO₂

Lastly, the Examiner asserted that the instant specification itself notes the equivalency of ammonium fluoride to tetramethyl ammonium fluoride. Applicants strongly but respectfully disagree. The specification states that tetraalkyl ammonium fluoride is not equivalent to ammonium fluoride, as set forth below. The specification sets forth on page 3, lines 23-27 as follows:

As the pressurized CO₂ is not enough by itself to remove residues, the pressurized CO₂ of the present invention, to which an additive and a co-solvent are added, is used as a remover for removing residues from the object. The additive used for this purpose can remove residues but cannot substantially dissolve in CO₂ by itself. The co-solvent used for this purpose can make the additive dissolved or dispersed homogeneously in CO₂.

As recited above, the additive ammonium fluoride is not soluble in a co-solvent containing a hydroxyl group in supercritical CO₂ conditions. The specification particularly points out the differences in properties of dissolving in an alcohol co-solvent where the fluorides of additives have alkyl groups or hydrogen atoms on page 4, lines 7-28 (emphasis added):

The kind and amount of the co-solvent are selected depending on the kind and amount of the additive to CO₂. The amount of the co-solvent is preferably five times or more

than that of the additive because the remover easily becomes homogeneous and transparent. Alternatively, the remover may include the co-solvent in a range of 1 wt. % to 50 wt. %. If more than 50 wt. % of the co-solvent is added, the penetration rate of the remover decreases due to less amount of CO₂. It is preferable to use a remover including CO₂, alcohol as the co-solvent, quaternary ammonium fluoride and/or quaternary ammonium hydroxide as the additive because these additives are well dissolved in CO₂ by alcohol and are CO₂-philic.

According to the present invention, it is preferable to contact the object with a remover composed of CO₂, a fluoride of formula NR₁R₂R₃R₄F, (R represents a hydrogen or alkyl group), and a compound having hydroxyl group, while CO₂ is high pressurized or is preferably kept at a supercritical condition. This remover is more effective to remove ash residues from the semiconductor wafer. The fluoride may be any fluoride of formula NR₁R₂R₃R₄F where R represents a hydrogen or alkyl group, e.g. ammonium fluoride, tetramethylammonium fluoride, and tetraethylammonium fluoride. It is preferable to use the fluoride with Rs being alkyl groups, such as tetramethylammonium fluoride and tetraethylammonium fluoride because such fluorides are CO₂-philic. In the present invention, the remover may include the fluoride preferably in the range from 0.001 wt % to 5 wt % of the remover, more preferably in the range from 0.002 wt % to 0.02 wt % of the remover.

Thus, the specification clearly states that tetraalkyl ammonium fluoride is not equivalent to ammonium fluoride.

Therefore, one of ordinary skill in the art would not and could not achieve all the features as recited in claim 1 by combining Vaartstra and Skee with Mullee. Accordingly, claim 1 is not obvious in view of all the prior art cited.

Claims 5, 19, 20, 23

Claims 5, 19, 20, and 23 have substantially the same features as those of claim 1, at least with respect to a composition comprising a carbon dioxide, an additive comprising an additive for removing the residues comprising a fluoride having a formula NR₁R₂R₃R₄F, where each of R₁, R₂, R₃, and R₄ is an alkyl group, and a quaternary ammonium hydroxide; and a co-solvent for dissolving said additive in said CO₂ at a pressurized fluid condition, wherein at least said carbon dioxide is in a supercritical state so as to maintain the composition comprising said carbon dioxide, said additive and said co-solvent as a single composition and wherein weight percents of said carbon dioxide, said additive and said co-solvent are such that the composition comprising said carbon dioxide, said additive and said co-solvent effectively penetrates residues on the microstructure, and wherein the fluoride is selected from tetramethylammonium fluoride, tetraethylammonium-fluoride, tetrabutylammonium fluoride, tetrapropylammonium fluoride, choline fluoride, and mixtures thereof. As

such, the arguments set forth above are equally applicable here. Claim 1 being allowable, claims 5, 19, 20, and 23 must also be allowable.

Claims 7, 8, 14, 16, 18, 24-26

As to dependent claims 7, 8, 14, 16, 18, and 24-26 the arguments set forth above with respect to independent claims 1, 5, and 19 are equally applicable here. The corresponding base claim being allowable, claims 7, 8, 14, 16, 18, and 24-26 must also be allowable.

The Second 35 U.S.C. §103(a) Rejection

Each of claims 21 and 22 was rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Mullee in view of Vaartstra, Skee, and Xu (U.S. Pub. No. 2003/0125225), and further in view of McCullough (U.S. Pat. No. 5,976,264). The Examiner further cited the secondary reference of Xu (U.S. Pub. No. 2003/0125225). Upon the inquiry by telephone on July 17, 2008, the Examiner admitted that Xu was mistakenly cited and should not be cited. This rejection is respectfully traversed for the reasons set forth below.

The tertiary reference of McCullough fails to provide any disclosure, teaching or suggestion that make up for the deficiencies in Mullee, Vaartstra, Skee and the knowledge generally available to one of ordinary skill in the art at the time the invention was made. Rather, even if all the references were combined, their combination would still fail to show or suggest a composition comprising a carbon dioxide, an additive comprising an additive for removing the residues comprising a fluoride having a formula $NR_1R_2R_3R_4F$, where each of R_1 , R_2 , R_3 , and R_4 is an alkyl group, and a quaternary ammonium hydroxide; and a co-solvent for dissolving said additive in said CO_2 at a pressurized fluid condition, wherein at least said carbon dioxide is in a supercritical state so as to maintain the composition comprising said carbon dioxide, said additive and said co-solvent as a single composition and wherein weight percents of said carbon dioxide, said additive and said co-solvent are such that the composition comprising said carbon dioxide, said additive and said co-solvent effectively penetrates residues on the microstructure, and wherein the fluoride is selected from tetramethylammoniumfluoride, tetraethylammonium-fluoride, tetrabutyl-ammoniumfluoride, tetrapropylammoniumfluoride, choline fluoride, and mixtures thereof. Accordingly, claims 21 and 22 must be allowable.

The Third 35 U.S.C. §103(a) Rejection

Claim 9 was rejected under 35 U.S.C. §103(a) as being allegedly unpatentable over Mullee in view of Vaartstra and further in view of McCullough or WO 01/33613 (hereinafter WO '613). This rejection is respectfully traversed for the reasons set forth below.

The tertiary reference of McCullough or WO '613 fails to provide any disclosure, teaching or suggestion that make up for the deficiencies in Mullee, Vaartstra, and the knowledge generally available to one of ordinary skill in the art at the time the invention was made. Rather, even if they were combined, such a combination would still fail to show or suggest the combination of features recited in claims 9. Accordingly, claim 9 must be allowable. Accordingly, claim 9 must be allowable.

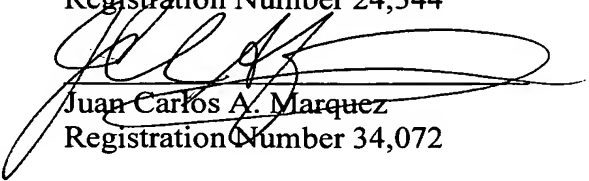
Conclusion

In light of the above Remarks, Applicants respectfully request early and favorable action with regard to the present application, and a Notice of Allowance for all pending claims is earnestly solicited.

Favorable reconsideration of this application is respectfully solicited. Should there be any outstanding issues requiring discussion that would further the prosecution and allowance of the above-captioned application, the Examiner is invited to contact the Applicants' undersigned representative at the address and phone number indicated below.

Respectfully submitted,

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